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CONTEMPORARY ISSUES

Intervention of the Renal Disaster Relief Task Force in the 1999 Marmara, Turkey earthquake

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Intervention of the Renal Disaster Relief Task Force in the 1999 Marmara, Turkey earthquake.

Background. Major earthquakes are followed by a substantial number of crush syndromes and pigment-induced acute renal failures (ARFs). The natural evolution of this problem rapidly leads to death. Today's possibilities of dialysis therapy enable saving numerous lives that otherwise would be lost. Currently, the primary problem is organizational, if huge catastrophes occur and complex therapeutic options need to be offered to a large number of victims.

Methods. Following the 1988 Spitak earthquake in Armenia, the International Society of Nephrology (ISN) established the Renal Disaster Relief Task Force (RDRTF) in order to anticipate organizational problems related to renal care in the aftermath of large natural and human-made catastrophes. The proposed concept was one of a dialysis advance team, which would assess the needs and possibilities of dialysis treatment, to be followed by supportive manpower and supplies. This article describes the organizational aspects of a rescue action that was undertaken following the Marmara earthquake, which occurred on August 17th, 1999, in northwestern Turkey. In conjunction with Médecins Sans Frontières, a team landed at Istanbul Airport less than 22 hours after the disaster, and logistic and material support as well as manpower were provided over a period of approximately one month. Specific attention was paid to the choice of the renal replacement therapy, the transport of victims and materials, the implementation of preventive rehydration, and the problem of chronic renal failure patients dialyzed in the damaged area.

Conclusions. We demonstrate how previously anticipated international support may offer moral, financial, as well as logistical help to local nephrological communities confronted with serious disasters.

On Tuesday, August 17th, 1999, at 3:01 a.m. local time, a major earthquake (7.4 on the Richter scale) struck northwestern Turkey. The affected zone covered a broad area surrounding the Marmara Sea (Fig. 1). Mortality was estimated at >17,000, with 35,000 wounded and 600,000 homeless. An unprecedented number of crush syndrome patients needing dialysis were observed (N = 477).

A team from Médecins Sans Frontières (MSF; Doctors Without Borders) landed at the Istanbul Airport less than 22 hours later. One of the aims was to offer nephrologic support to patients suffering from post-traumatic acute renal failure (ARF), as a collaborative action between MSF and the Renal Disaster Relief Task Force (RDRTF) of the International Society of Nephrology (ISN). The help consisted both of material and organizational support, and the sending of personnel to decrease the workload for the local medical professionals (Table 1).

Several articles concentrate on the organization of general support after earthquakes [1–6], but few details are available on the practical organization in the field of large-scale renal disaster relief, apart from two articles offering general information [7, 8]. During some interventions, support to severely affected ARF patients was even withheld [4] or, forced by circumstances, was started after a delay of several days [7]. The present international action was launched within 24 hours.

This article analyzes the activities of the RDRTF during this natural disaster. It might be useful for the organization of future aid, since the Marmara earthquake occurred in a large, densely-populated area and had an extraordinary number of casualties, deaths, and ARF patients. In addition, this article aims at drawing the attention of the medical community to the possibilities offered by the RDRTF.

CRUSH SYNDROME AND RHABDOMYOLYSIS

Major earthquakes are followed by a substantial number of crush syndromes, provoking rhabdomyolysis and pigment-induced ARF [9, 10]. The incidence of crush syndrome has been estimated at 2 to 5% at least [11, 12]. Approximately 50% of the patients with crush syndrome develop ARF, and approximately 50% of those with ARF

Key words: crush syndrome, acute renal failure, disaster relief, dialysis therapy, rhabdomyolysis, catastrophe, Marmara earthquake, rescue.

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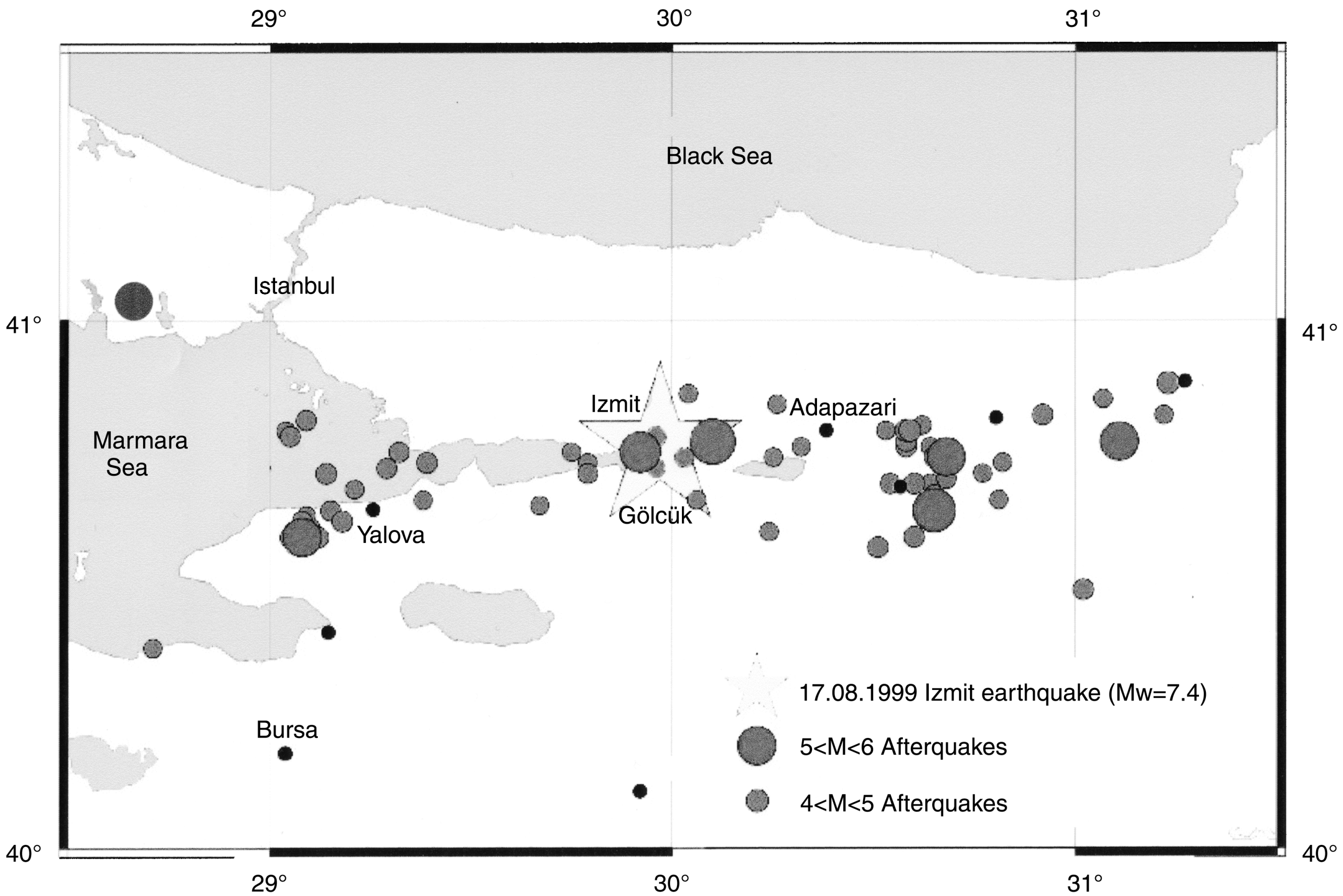

Fig. 1. Geographical distribution of the 1999 Marmara earthquake. The epicenter (star) was located in Izmit (Kocaeli). The most severely affected locations were Izmit, Adapazari (Sakarya), and Gölcük. Yalova was mainly damaged by a severe aftershock on September 13th. On November 12th, a new earthquake (7.2 on the Richter scale) struck Düzce (at the extreme east of this map). The circles indicate severe aftershocks with an intensity above four on the Richter scale. Information was obtained with the help of Dr. Sahin Akkargan, Istanbul University.

Table 1. Support offered

Source	MSF/ISN	Other than MSF/ISN
Personnel		
Nephrologists	6	—
Nurses	29	3
Technicians	1	2
Total	36	5
Material		
Dialyzers	5,000	1,800
Central vein catheters	536	—
PD catheters	100	—
Dialysate concentrate	13,500L	1,000L
Dialysis machines	5[a]	111
Kayexalate	10 kg	—
Water treatment systems	—	2

[a] Temporary

will need dialysis [10]. Table 2 summarizes the reported experience with earthquakes during the last 15 years [2, 5, 7, 9, 10, 13–20]. In the Marmara earthquake, the proportion of dialyzed patients with nephrologic problems was unprecedentedly high. Undeniably, the relationship between the number of deaths, injuries, crush syndrome, and ARF depends on many accidental factors such as the severity of the disaster, the quality of the buildings, and local medical resources. Nevertheless, it is conceivable that the immediate launching of international support has played a substantial role in the timely accomplishment of massive dialytic help.

We defined acute renal failure as a crush syndrome with related nephrological problems for which dialysis was necessary. On the other hand, patients with the crush syndrome were defined as patients presenting with crush injury and developing oligoanuria (<400 mL/day) and/or needing dialysis treatment. Patients with nephrological problems were defined as patients needing dialysis or characterized by one of the following variables: oliguria (urine output ≤400 mL/day), BUN >40 mg/dL, serum creatinine >2.0 mg/dL, uric acid >8.0 mg/dL, potassium >6.0 mEq/L, phosphorus >8.0 mg/dL, and calcium <8.0 mg/dL.

The mortality of rhabdomyolysis-associated ARF has been estimated to be approximately 40% [21]. The mor-

Table 2. Major earthquakes of the last 15 years with reported statistics in the literature

Location, country (*year*)	Reference	Mortality	Crush syndrome	Dialyzed	Immediate international action
Mexico City, Mexico (1985)	[13]	3,000–4000	?	?	–
Spitak, Armenia (1988)	[5, 7, 9, 13, 14]	25,000	>1,000	323	–
Loma Prieta, California (1989)	[15, 16]	63	?	?	–
Northern Iran (1990)	[17]	>40,000	?	156	–
Erzincan, Turkey (1992)	[18]	653	?	6	–
Northridge, California (1994)	[19]	33	?	?	–
Hanshin, Japan (1995)	[2, 10, 20]	5,000	±500	123	–
Marmara, Turkey (1999)		>17,000	500[a]	477	+

[a] Patients with the crush syndrome were defined as patients presenting with crush injury and developing oligo-anuria (<400 mL/day) or needing dialysis treatment for at least one day

tality for dialyzed patients after the Marmara earthquake is estimated at only ±17%, attributable to rapid response, hemodynamic support, and intensive dialytic treatment. Search and rescue are only the first elements in a multiphase response, whereby preventive measures to avoid ARF and the mobilization of dialytic resources are at least as important as the extrication of the victims [13].

THE ISN RENAL DISASTER RELIEF TASK FORCE

Muscular damage to a large extent is induced during reperfusion [22] so that ARF mostly develops after release of the victim from under the rubble [23]. Rhabdomyolysis is associated with hyperkalemia, hypocalcemia, hyperuricemia, hyperphosphatemia, metabolic acidosis, and severe volume depletion [13, 24–26]. The natural evolution of this problem rapidly leads to death, as originally stated by Bywaters and Beall in an era when no dialysis was available [27]. Today's possibilities of dialysis therapy enable saving numerous lives that otherwise would be lost [28].

The RDRTF was founded in 1989, following the Spitak earthquake in Armenia [8]. Based on this experience, where before day 8 after the earthquake little acute dialysis was initiated [8], and in order to anticipate problems of that extent, organizational structures were created in advance for three principal areas (Northern, Central, and South America; Southeast Asia; Minor and Middle Asia, Northern Africa, Europe). The concept proposed was one of a dialysis advance team, which would assess the needs and possibilities for dialysis, to be followed by supportive manpower and material. Stocks of hardware and lists of volunteers (nurses and nephrologists) were composed to be available for future earthquakes. Lameire et al describes a more thoroughly detailed organization of the European Branch of the Task Force [29]. Besides some limited interventions, the present action was the first instance at which the European Branch became fully operative in conjunction with an earthquake.

From the moment the decision was made that an intervention was needed (Fig. 2), the next step was to decide whether enough undamaged dialysis units were located within reasonable distance from the disaster area and whether the hemodialysis positions and other infrastructure were sufficient to manage the patient load. A local coordinator was designated in agreement with the Turkish Society of Nephrology, and the most important needs were prioritized and transmitted to the global coordinator (N.L.) at the European headquarters in Ghent (Belgium). Then, distribution of the personnel/equipment according the needs and the storage capacity for the materials were defined.

PRACTICAL IMPLEMENTATION OF THE ARF PROGRAM

The decision for intervention was made after several hospital visits (R.V.) during the night of arrival (August 18th, 5.00 a.m., local time), and this was communicated to the European RDRTF coordinator (N.L.) at 9.00 a.m. the same day, that is, 30 hours after the disaster.

Within a few hours, we knew of at least three units in Istanbul that were able to take in the ARF patient load (Istanbul, Cerrahpasha, and Marmara Medical Faculties; Table 3), taking into account the possibility of treating two ARF patients per position per day if all chronic patients remained in the unit (restriction to 2 chronic dialysis sessions per week). If the chronic patients were transferred to other (low-care) units, the number of ARF patients could be increased to five. From day 2 on, we became aware of dialysis facilities treating substantial numbers of patients in Ankara and Bursa as well (Table 3). Adequate follow-up necessitated repeated visits and/or calls to all units involved, control of the needs and the patient numbers, and evaluation of the clinical conditions, as well as repeated briefings and debriefings with the other members of the MSF team. A usual working day lasted from 5 a.m. to 12 p.m.

Reference centers were defined as being located at a safe distance from the epicenter if they were at least 40 to 50 km from the damaged area.

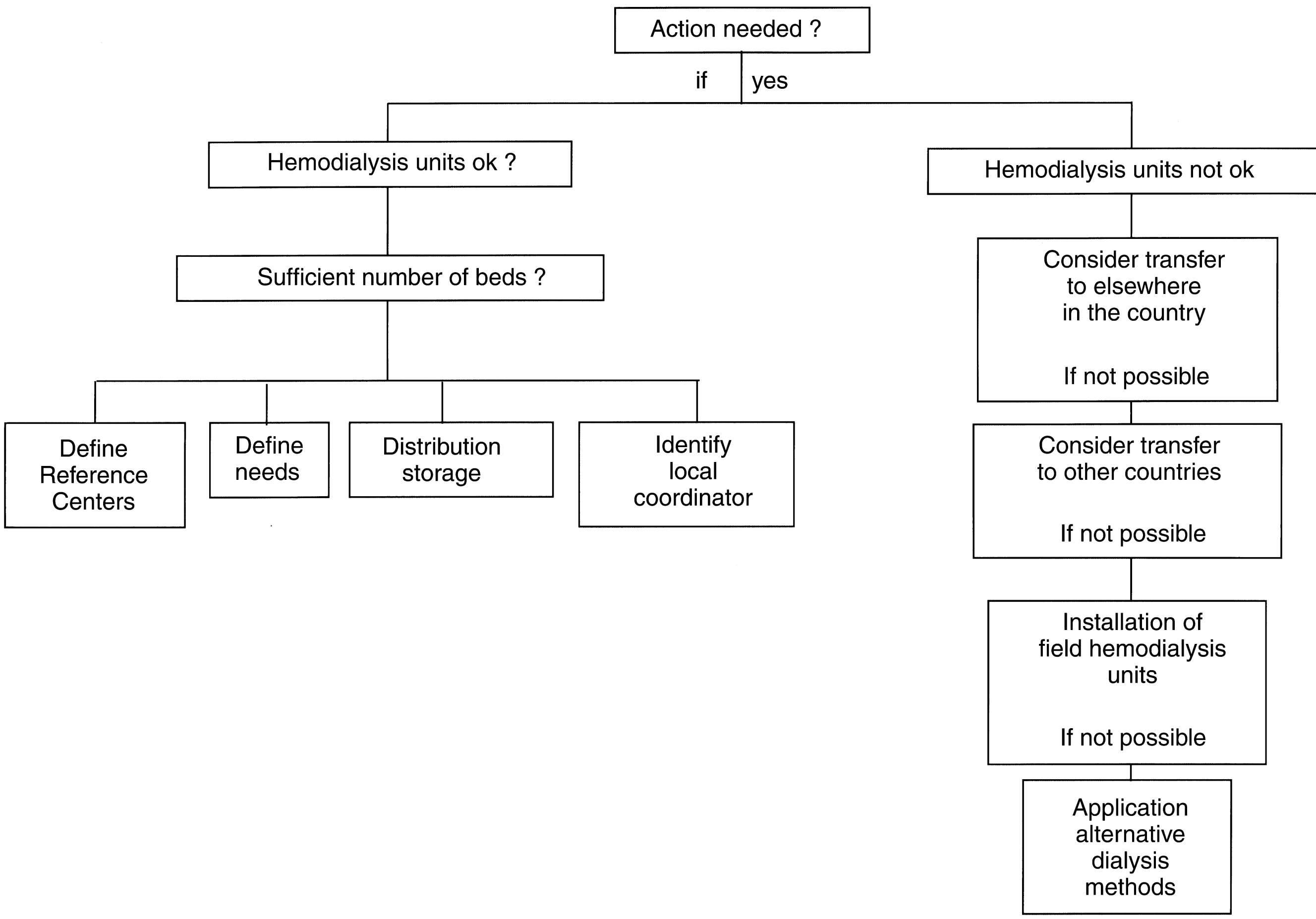

Fig. 2. Flow chart of the planning of the action in the presence (left) or absence of sufficient dialysis infrastructure (right).

From the first day after arrival, contacts were made with the local governmental instances (Istanbul and Ankara) and with the different crisis centers to obtain permission for our activities and the import into the country of the equipment. Import and local transport were confined to MSF, which has a long experience with this type of action. Materials were stored in Istanbul at Marmara University, Medical Faculty, and they were distributed from that central location to the other hospitals. Stock management was a common task of the MSF and the RDRTF teams.

Non-Turkish aid providers were coupled to Turkish colleagues, increasing efficiency and avoiding as much as possible any organizational conflicts as well as cultural and linguistic misunderstandings.

Within a few days, more than 600 patients suffering from nephrological problems had been traced, of which a maximum of 477 would need dialysis, and 500 conformed with the previously mentioned definition of the crush syndrome. In total, approximately 5000 acute dialysis sessions were performed. At week 2, 363 patients were still on dialysis (Fig. 3). Mortality at that moment amounted to 48, while 29 patients had been discharged from the nephrological units. Mortality and discharges amounted to 83 and 126 at week 4 and to 98 and 650 at week 8, respectively (data as they were known to us at these time points; a more detailed analysis will be available in the future). It should be stressed that discharges from nephrological units in most instances were not discharges to the patient's homes, but to other departments (for example, orthopedic or plastic surgery clinics).

Patient transport

One of the major problems in the attempts to offer dialysis to crush victims with ARF was the organization of their transport to hospital units outside the damaged area with sufficient possibilities. This was especially a problem during the first 48 hours after the disaster, when most roads were destroyed, and the situation was extremely chaotic. In this context, it is important to stress that the damaged area stretched over a large and densely populated area. These problems were partly overcome by transporting victims via the Marmara Sea, since many

Table 3. Hospitals treating acute renal failure patients by dialysis at day 10 (August 27th, 1999)[a]

Location	Name of the hospital	Patients with nephrological problems	Patients on dialysis
Bursa	Uludag Med Fac	90	49
	State Hosp	14	13
Istanbul	Marmara Med Fac	85	46
	Istanbul Med Fac (Çapa)	62	25
	Göztepe Social Security Hosp	60	36
	GATA-Haydarpasa Hosp	46	14
	Kartal State Hosp	40	25
	Cerrahpasha Med Fac	33	21
	Haydarpasa Numune Hosp	18	11
	Sisli Eftal Hosp	13	10
	American Hosp	12	12
Ankara	GATA-Ankara Hosp	46	14
	Baskent Med Fac	43	17
	Ankara Med Fac	27	16
	Ankara Numune Hosp	22	17
	Hacettepe Med Fac	20	11
Eskisehir	Osman Gazi Med Fac	23	23
Other		63	30
Total		717	390

[a] Hospitals with minimum 10 dialysis patients; only the patients known to us at that moment are mentioned

of the affected cities such as Gölcük and Yalova were located along its coastline, as was also the city of Istanbul, where many of the primary reference centers were located. Transport was organized as well by civilians and private businesses, as by the Turkish Red Crescent and the Turkish Army.

Laboratory support

Biochemical determinations were essentially obtained in the laboratory units of the hospitals in the damaged area and of the reference centers. The biochemical possibilities in the damaged area were restricted, attributable to both damage of the laboratory infrastructure and the enormous patient overflow. On the other hand, for most of the patients who reached the reference hospitals, the most essential laboratory techniques were available, although not always on a continuous basis because of the large number of determinations. Especially when dilutions were to be applied (for example, for CK determinations), the necessary time was not always available. On the other hand, however, hematocrit, hemoglobin, plasma Na^+, K^+, Ca^{++}, P, CK, alanine aminotransferase (ALT), aspartate aminotransferase (AST), blood urea nitrogen (BUN), creatinine, and albumin were available for almost all patients at regular intervals.

CHOICE OF RENAL REPLACEMENT STRATEGY

In order to choose a dialytic strategy, the specific characteristics of the crush syndrome should be taken into account: extensive muscle necrosis, risk for abdominal trauma, bleeding risk, frequent need for fasciotomy or amputations, and frequent hyperkalemia [24, 28]. Taking these into account together with the local capabilities, the option was taken for intermittent hemodialysis in the majority of patients.

It must be acknowledged that this model applies only for a country such as Turkey, which has an adequate hemodialysis infrastructure. This strategic plan might be different in other circumstances. However, regarding our experience at the Marmara earthquake, it seems that peritoneal dialysis by itself was not sufficient to treat most of the patients, mainly because of the high risk for hyperkalemia and high catabolic rate. As a result, either hemodialysis or hemofiltration techniques should be available where needed in centers treating these cases.

Nondialytic treatment of hyperkalemia

One of the main problems was the institution of therapy against hyperkalemia before victims reached an institution where dialytic possibilities were available, or immediately upon their arrival, before they could be connected to a dialysis machine. Of the many available conservative therapeutic options (calcium salts, bicarbonate, hypertonic glucose, K^+ binders, β agonists), only K^+ binders were considered safe enough to be administered in conditions in which appropriate supervision was often lacking. In addition, it should be taken into account that most other methods only cause a temporary K^+ shift into the cellular pool, which quite soon is followed by a return in the opposite direction. It can be argued that the potential to remove potassium by intestinal binders might be minimal compared with the immense potassium

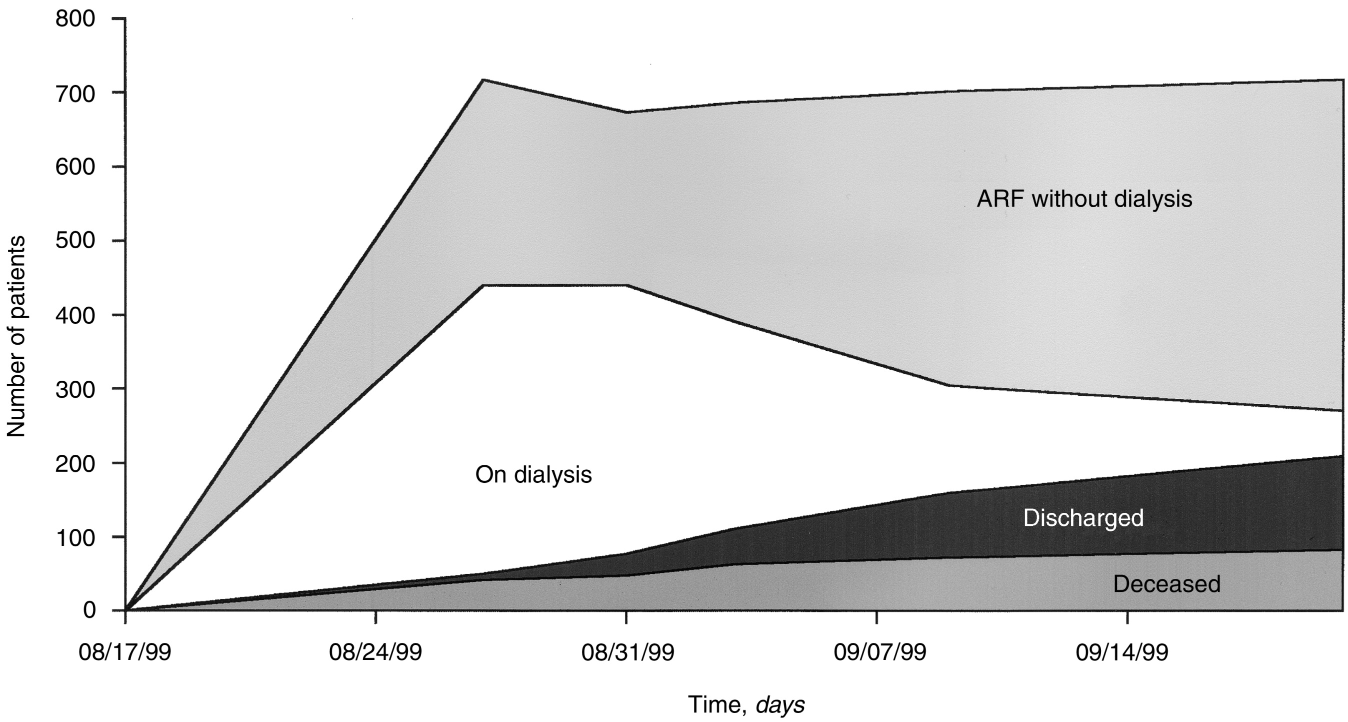

Fig. 3. Evolution of acute renal failure (ARF) patients and their condition during the first month after the earthquake. Data relate to the numbers known to us at the moments indicated.

load from the necrotic muscle cells. On the other hand, all means to restrict the potassium load in the body were welcomed. As a K^+ binder, Ca-kayexalate was used in conjunction with sorbitol. Both compounds were not available in sufficient quantities in the damaged region, and thus, they were brought into Turkey by each new member of the team who entered the country. In spite of all of these efforts, we are aware of a number of victims who died from cardiac arrest, probably attributable to hyperkalemia, shortly after their arrival in the reference hospitals.

TRANSPORT OF MATERIAL

Delivery was delayed, although transport had been planned carefully in advance. This delay related to (*1*) a larger need for transport of non-nephrological material than originally anticipated and (*2*) lack of space, necessitating selection between primary care goods and dialysis material. As dialysis would only become possible after successful primary care, the transport of dialysis material was sometimes postponed. For that matter, alternative transport methods were developed. Especially the small volume cargo (for example, central vein catheters or kayexalate) was transferred in the hand luggage of new members of the teams entering the country.

PREVENTIVE REHYDRATION

Acute renal failure caused by crush syndrome can be prevented by timely and sufficient, preferably alkaline fluid administration [23, 30], as originally suggested during World War II [31]. However, it should be recognized that to date the successful application of this strategy has essentially been restricted to relatively smaller disasters in comparison to the 1999 Marmara earthquake. Fluid administration preferably should be started at the site of the catastrophe [24].

As early as 12 hours after our arrival, it became clear that some of the ARF patients were severely dehydrated. This was not surprising for several reasons: (*1*) the chaotic conditions of extrication and transport; (*2*) the outside temperatures, up to 38°C in the shade, with most of the local hospitals destroyed so that patients were treated in open air and in the sun; and (*3*) the severity of muscular damage, illustrated by the fact that at least 50% of the patients needed fasciotomy. It is known that many liters of extracellular volume can be sequestered in severely damaged muscles [32].

Strategies were developed to pursue early rehydration. First, the general practitioners working with MSF in the dispensaries on the field were briefed about the characteristics of the crush syndrome as well as the appropriate fluid administration and referral procedure. They were asked to transmit this information to the local primary care doctors, responsible for triage and first aid. Second, 400 pamphlets were made in Turkish language in which the same advice was given and distributed at locations where primary care and triage were taking place (Table 4).

Table 4. Pamphlet distributed in primary care centers regarding ARF and fluid needs

INTERNATIONAL SOCIETY OF NEPHROLOGY
RENAL DISASTER RELIEF TASK FORCE

Acute renal failure is a common complication of crush injury.

Diagnosis:
- No or little urine.
- Red or brown urine.
- Elevated creatinine.

If these signs are present, or if the limbs are severely affected, the patients need immediately to be transported to a hospital with dialysis and intensive care facilities.

Prevention:
- Fluid as early as possible.
- Try to find a vein in arm or leg already if the patient is under the rubble.
- Preferable fluid combination (for 2 L):
  - 1 L of isotonic saline
  - 1 L glucose 5% + 100 mEq bicarbonate
- Start 1 L before evacuation from under the rubble (if possible).
- Continue at 3 to 6 L per day depending on the urinary flow.
- Add 10 cc mannitol per hour if there is more than 20 mL/h urine.

If urinary flow does not increase above 800 mL per day after 1 day, also please transfer the patient to the appropriate hospital.

Should larger volumes than the 6 L suggested in the pamphlet be advised? In the chaotic conditions following massive natural catastrophes, aggressive fluid politics might turn out to be unrealistic [17], especially in older patients or in cases of delayed extrication [10, 13]. We therefore opted for a more conservative attitude than the one suggested by Better and Stein [24].

In addition, this somewhat more restricted fluid administration schedule was more realistic in view of the high number of victims of the Marmara catastrophe, compared with the Better experience. Better's experience was obtained after a disaster with a limited number of ARF patients, developing this condition in a well-defined and restricted geographic area.

Finally, one should consider early identification of heme pigment losses in the urine by the application of dipstick tests to detect heme in the urine, allowing a more precise definition of the potential risk to develop ARF.

DIALYSIS CONDITIONS IN THE DAMAGED AREA

Dialysis facilities in the most severely affected areas were not used for the treatment of ARF (Fig. 1); medical professionals in that zone concentrated on patient selection, referral, and immediate transfer rather than on complex secondary support measures. Intensive care units and surgical theaters were not operative. Also, in previous earthquakes, it appeared that crush patients who were treated in affected hospitals carried a mortality that was approximately three times higher than evacuated patients, and that it was rewarding to transport them out of the affected area [20].

Before the earthquake, 531 chronic renal failure patients underwent hemodialysis in the most damaged area. A detailed assessment revealed that the total number of operative dialysis units had been reduced from 11 to 5. Similarly, the available number of machines had been reduced from 115 to 53. The chronic patient number decreased to 265. It should be considered that the majority of the remaining 266 patients had left the disaster area to obtain dialysis elsewhere [33], even taking into account that some might have been victims of the disaster and that it is well known that cardiovascular mortality and morbidity rise spectacularly among any population during the first weeks after an earthquake [34]. Conceivably, only the least fortunate patients and those without family remained in the disaster area. The buildings in which dialysis took place were of dubious quality, with a risk for collapse when a new earthquake would occur. It was therefore considered appropriate to construct new dialysis facilities, preferably low prefab buildings in safe areas. Quite quickly, the Turkish Society of Nephrology took initiatives in this matter.

Hospital staff were killed or injured as well, or they had problems with family members and/or housing so that staff continuity was frequently disrupted. The local coordinator (M.S.S.) took care to redistribute nurses from elsewhere in Turkey in order to cope with this problem.

FUTURE PERSPECTIVES

The present observations might be helpful in establishing future strategies if disasters occur in areas where no dialysis facilities are available. The following options should be taken into consideration (Fig. 2, right section): (*1*) evacuation of ARF patients to more remote cities, if necessary abroad; (*2*) alternative transportation means (boat, plane, helicopter) since evacuation by road might impose problems; and (*3*) the construction of emergency dialysis units in tents or prefab buildings. We believe that in every earthquake-prone area, there is a need to organize a consensus with the several medical authorities of different neighboring countries to anticipate problems. Maps of the countries at risk and a complete list of all dialysis facilities in those countries should be prepared in advance. Pamphlets with instructions on fluid administration should be available in advance in the different languages of the areas at risk so that they can be distributed from the moment the first assessment teams reach the damaged area. Periodic meetings regarding the first and second line treatment strategies should be organized in potential distress areas, not only for the nephrologists but also for other specialists, general practitioners, and nurses.

CONCLUSIONS

The primary aim of this mission was to coordinate the dialysis facilities, to register the needs of personnel and equipment, and to fill these in by donations from MSF/ISN. Facilitating factors were: (*1*) the fact that most plans had been conceived during previous years when the RDRTF was first assembled and has been refined through different disaster experiences over the years; (*2*) the incorporation in the structures of the human and logistic resources of MSF; (*3*) the presence in the area of several local outstanding dialysis facilities, operated by experienced nephrologists and nurses; and (*4*) the excellent collaboration with the Turkish Society of Nephrology and the Turkish nurses and technicians.

The fact that this action was started immediately after the earthquake, with the presence of a initial MSF evaluation team within the first 24 hours, allowed that needs could be anticipated quickly and met before real deficiencies developed. Apart from material help, volunteers were sent into dialysis units in which a shortage of personnel was developing. Specific attention was paid to the selection of patients, identification of ARF, and preventive rehydration. One might argue that expensive support was offered for a limited fraction of the affected population. The rationale behind this action was that severe crush syndrome victims had cost a lot of effort to be extricated, and that it would be deplorable if not enough therapeutic possibilities would be offered, once they developed ARF.

It is difficult to translate the offered help into the number of saved lives. Nevertheless, it can be speculated that the moral as well as financial support offered by the international community has helped Turkish nephrologists to cope with the immense problems with which they were confronted [35, 36]. In addition, the experience gained in the aftermath of the Marmara earthquake will be of major help in improving the practical approach towards aid in cases of future earthquakes.

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